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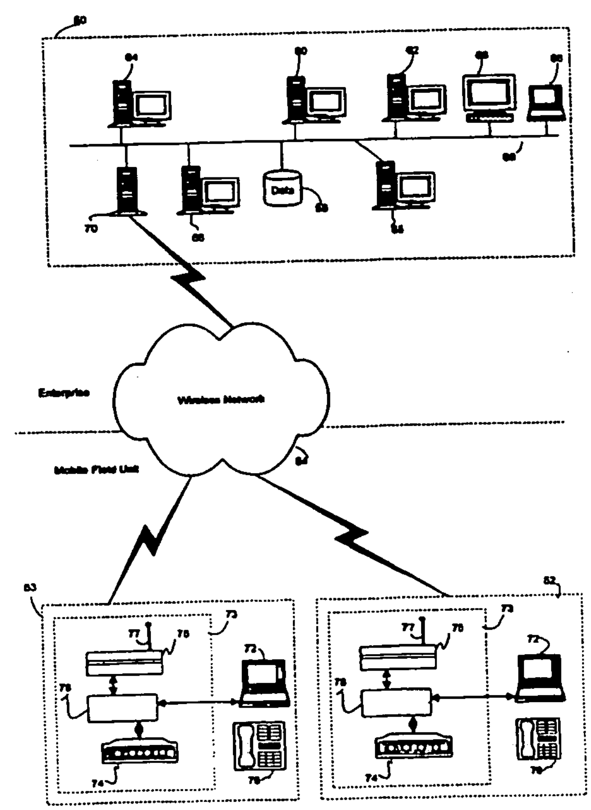
(54) Title: AUTOMATIC MOBILE CREW TRACKING SYSTEM WITH REMOTE ACCESS

(57) Abstract

A system for crew location and task assignment comprises an enterprise computing system (50), a mobile field unit (52), and wireless communication network (54) which supports transmission control protocol (TCP/IP). The enterprise computing network (50) comprises application programs (80) through which data related to the position of a mobile field unit (52) may be requested, various server machines (84) for storing position data, a local area network (LAN) connecting the server machines (84), and a gateway to the TCP/IP wireless network. A mobile field unit (52) comprises a receiver (97) for receiving position data from a positioning service, a processor (98) having instructions thereon for processing the position data, and a radio modem (86) for communicating the position data over the wireless network (54). The mobile field unit (52) and each machine in the enterprise computing system has a unique IP address assigned to it. Accordingly, commands and data can be communicated freely between all machines.



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AUTOMATIC MOBILE CREW TRACKING SYSTEM WITH REMOTE ACCESS

FIELD OF THE INVENTION

This invention relates generally to management information systems and more particularly to automated systems and methods for field crew location and route planning.

BACKGROUND OF THE INVENTION

Businesses such as utility companies which deploy numerous employees over a wide geographic area to service a dispersed infrastructure or client base are faced with the particularly cumbersome task of communicating work assignments and related data to personnel that are dispersed in the field. For example, a utility company is faced with the daunting task of maintaining an infrastructure that spans a potentially very large geographic area. When outages occur in a utility grid, field personnel must be dispatched to address the problem. Typically, field personnel are already in the field when new service tasks or work orders are generated. Thus, utility companies are faced with the very complex task of receiving work orders, identifying field personnel that are best suited for the job, and communicating to field personnel that a particular work order has been assigned to them.

Typically, work orders are assigned to field crews on the basis of training and experience. However, another important consideration when assigning work orders is a field crew's proximity to the work area. Generally, a central dispatcher or operations manager has no automated means to locate field crews. Rather, an operations manager must rely on voice communications from field crews as to their location. Location data gathered from field crews may not always be accurate or even a useful description of the field crew's position. Further, manually maintaining field location data for multiple field crews can be an unwieldy task; doing so for a large number of field crews can be overly burdensome, if not impossible. Additionally, even if field location data is made available it must be applied to a map in order for it to be useful in calculating proximity to work sites and thereby making decisions as to work order assignments. Presently, this task also is completed manually.

Thus, there is a need for an automated system and method for more advanced two way data communication between field personnel and a central office. In particular, there is a need for a system whereby accurate field location and position data is gathered for a field crew and automatically communicated to a central location or directly to other field crews deployed in the field.

SUMMARY OF THE INVENTION

Briefly, the present invention provides an automated system for gathering data related to the position of a field crew, communicating requests for the position data, and communicating the desired position in response to the request. The system comprises an enterprise computing system, at least one mobile field unit, and wireless communication network which supports transmission control protocol/internet protocol (TCP/IP). A mobile field unit

comprises a receiver for receiving position data from a positioning service, a processor having instructions thereon for processing the position data, and a radio modem for communicating the position data over the wireless network to the enterprise computing system or other mobile field units. The enterprise computing network comprises application programs through position data may be requested and viewed, various server machines for storing and receiving position data, a local area network (LAN) connecting the server machines, and a gateway to the TCP/IP wireless network. Each mobile field unit and machine in the enterprise computing system has a unique IP address assigned to it. Accordingly, commands and position data can be communicated freely between all machines.

According to another aspect of the invention there is provided a method for distributing position data. There is also disclosed a method for processing position data. According to still another aspect of the invention there is provided a method for formatting position data.

BRIEF DESCRIPTION OF THE DRAWINGS

Other features of the invention are further apparent from the following detailed description of presently preferred exemplary embodiments of the invention taken in conjunction with the accompanying drawings, of which:

Figure 1 is a schematic diagram of a system in accordance with the present invention;

Figure 2 is a diagram of software components of a system in accordance with the present invention;

Figure 3 is a diagram of software components of a system in accordance with the present invention;

Figure 4 is a diagram of a system in accordance with the present invention wherein data flow is shown directly between two mobile field units as well as between the mobile field units and the enterprise computing system;

Figure 5 is a flow diagram of process in accordance with the present invention for distributing mobile field unit position data;

Figure 6 is an illustration of an exemplary screen for selecting a mobile field unit for which position data is desired;

Figure 7 is an illustration of an exemplary screen for viewing mobile field unit position data;

Figure 8 is a flow diagram of a process in accordance with the present invention for processing requests for position data;

Figure 9 is a flow diagram of a process in accordance with the present invention for processing position data;

Figure 10 is a flow diagram of a process in accordance with the present invention for formatting position data;

Figure 11 is a diagram of software components and data flows in a system in accordance with the present invention; and

Figure 12 is a diagram of software components and data flows in a system in accordance with a second embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

The present invention provides systems and methods for field crew location and task assignment. More particularly, the invention comprises an automated system for the distribution of field crew position data to a central location as well as to field personnel dispersed over a wide geographic area. In a system in accordance with the present invention, position data which may be any type of data related to the position of the mobile field unit is gathered at the mobile field unit. In one embodiment of the invention the data is received from a global positioning system (GPS). For example, a system from Trimble Inc. may be used to deliver data in both standard and proprietary format. The

mobile field unit receives requests from other mobile field units and the enterprise computing system to transmit its position data. In response, the mobile field unit transmits the requested position data. The mobile field unit may also send position data on an interval basis in response to a request. In this case, a single request results in multiple instances of position data being transmitted. In the case that position data has been transmitted to the enterprise computing system, mobile field units may request the position data from the enterprise computing system.

It should be noted that the present invention may be incorporated in a system that is employed to distribute work orders and related data in addition to field crew position data. Such a system is described in co-pending PCT Patent Application serial no. (not yet assigned) (attorney docket no. ABME-0538), filed on even date herewith, entitled "Mobile Crew Management System," the contents of which are hereby incorporated by reference in their entirety.

Figure 1 graphically depicts a system in accordance with the invention. As shown, the inventive system comprises enterprise computing system 50, mobile field units 52 and 53, and wireless communication network 54.

Enterprise computing system 50 may comprise database servers 56 for fielding requests to data stored in database 58, hypertext transfer protocol (HTTP) servers 60 for fielding requests for web page data, monitoring server 62 for accepting and providing data regarding the status of work orders, file servers 64, and UDP servers 65 for receiving mobile field unit position data and fielding requests for field position data. While each of servers 56, 60, 62, 64, and 65 is represented by a separate machine in Figure 1, in some embodiments of the enterprise system a single machine may be configured to perform all of these operations. An enterprise computing system may also comprise workstations 66 from which various application programs may be accessed.

Servers 56, 60, 62, 64, and 65 and workstations 66 are interconnected through an Ethernet local area network (LAN) 68. LAN 68 supports TCP/IP and each of machines 56, 60, 62, 64, 65, and 66 is uniquely identified with an IP address. Gateway 70 provides a communication connection between LAN 68 and wireless TCP/IP network 54.

In a typical application of the inventive system, enterprise computing system 50 is located at a central office, operations center, or dispatching center. As is explained in greater detail below with reference to Figures 2 and 3, position data for mobile field units 52 may be requested using an application program at enterprise system 50. Upon receipt from the mobile field unit, the position data is stored on enterprise system 50. The position data may be displayed at enterprise computing system 50 and also may be transmitted upon request to mobile field units 52.

Mobile field units 52 and 53 comprise position data unit 73. Position data unit 73 comprises position data receiver 75 having receiving antenna 77 operably connected thereto. Position data receiver 75 operates to receive positioning data from a global positioning system. Typically position data receiver 75 compiles latitude, longitude, velocity and direction data from the GPS system. Receiving antenna 77 typically operates by receiving signals from satellites and therefore may require line of site access to the satellites. Thus, when mobile field unit 52 is located within a vehicle, antenna 77 may be mounted on the exterior of the vehicle.

Position data unit 73 also comprises wireless radio modem 74. Wireless radio modem 74 provides a means for communicating over wireless network 54 with enterprise computing system 50 and other field units. Wireless radio modem 74 supports point-to-point (PPP) protocol and TCP/IP protocol over wireless radio network 54.

Position data unit 73 further comprises processor 78 which has stored thereon computer readable instructions for processing position data received at receiver 75. Processor 78 is operable to communicate with radio modem 74 and is therefore able to communicate the processed position data to enterprise computing system 50 or other mobile field units via wireless network 54.

It should be noted that while the components of position data unit 73, i.e. receiver 75, radio modem 74, and processor 78, are shown separately in Figure 1, these components might be embodied in a single physical device.

Mobile field units 52 and 53 optionally may comprise computing device 72 which may be a portable computer, a personal digital assistant (PDA), or similar device. Typically computing device 72 comprises a processor, random access memory (RAM), web browser software for internet and intranet communications, and an interactive display mechanism. Computing device 72 may also include: storage capability (flash or electro-mechanical), a serial interface, an audio playback device, and software to support a TCP/IP protocol stack and PPP protocol. It should be noted that any or all of the components of position data unit 73, i.e. processor 78, radio modem 74, and receiver 75, may be embodied in computing device 72.

Mobile field units 52 and 53 optionally may also comprise a wireless two-way voice communication device 76. Device 76 may be integrated with computing device 72 or may be a separate radio device, cellular phone, or digital cellular phone.

Each field crew is assigned a mobile field unit. Thus, although only two are shown in Figure 1, numerous mobile field units may be deployed and operating at once. Each mobile field unit 52 has an IP address assigned to it. Further, enterprise computing system 50 comprises a database of entries indicating for each field unit, the field crew

which has the unit. Thus, when field unit position data is needed or a work order is assigned to a particular field crew, the inventive system automatically routes the appropriate commands and data as described below and in co-pending PCT Patent Application serial no. (not yet assigned) (attorney docket no. ABME-538) entitled "Mobile Crew Management System," to the appropriate mobile field unit. Field crews are free to access enterprise computing system 50 to gather position data for other field crews or to gather data that may be helpful in completing an assigned work order. Furthermore, field unit position data may be accessed at a first mobile field unit 53 directly from another mobile field unit 52 without accessing enterprise computing system 50.

Wireless radio network 54 provides TCP/IP communication between enterprise computing system 50 and mobile computing devices 52 and 53. As previously noted, each mobile field unit 52 is given a unique IP address. Similarly, machines on enterprise computing network 50 are given a unique IP. Because wireless radio network 54 supports TCP/IP, routing of data and commands between mobile field units 52 and 53 and enterprise computing system 50 can be accomplished by existing network techniques. Further, mobile field units 52 and 53 can be arranged into various network configurations such as subnets and intranets and in theory, if the appropriate gateways are arranged, can be accessed via the Internet.

IP addressing allows for commands to be routed to, and data accessed from any machine in the network. Thus, data and/or a command may be transmitted via gateway 70 to wireless radio network 54 and delivered at any particular mobile field unit 52. Similarly, data and/or a command may be transmitted from mobile computing device 52 via modem 74 to wireless network 54 which delivers the data and/or command

to a particular machine designated by a unique IP address on enterprise computing system 50.

Preferably, wireless network 50 employs native TCP/IP. However, any network type may be employed provided it can be adapted to support TCP/IP. Thus, wireless network 54 may be any of the following network types: a CDPD public network (packet-switched); a radio packet-switched network (adapted for TCP/IP); a tariff/non-tariff-based network; or a Personal Communication Systems network(circuit-switched). A system in accordance with the invention can be implemented at any location that one of these network types exists. These alternative communication networks are discussed in greater detail in co-pending patent application entitled "Mobile Crew Management System."

Two alternative embodiments of the software components of the present invention are described below. A first embodiment employs UDP client and servers on enterprise computing system 50 and mobile field unit 52 to communicate field crew position data. A second embodiment employs an HTTP server on mobile field unit 52 and an HTTP client on enterprise computing system 50. Both embodiments are operable to pass field unit position data to enterprise computing system 50 or other field units 53.

Figure 2 is a diagram of software components comprised in a first embodiment of a system in accordance with the present invention wherein UDP technology is employed to communicate field unit position data. As shown, in enterprise computing system 50, numerous application program components or clients 80 may exist. Preferably these are written using the JAVA programming language so as to be operable on platforms running various operating systems. Each application 80 may serve a particular purpose with respect to managing work orders and monitoring the progress of those work orders. UDP position tracking application 83 is employed by operators of the system to manage position

data for various mobile field units. In particular, UDP tracking application 83 may be employed to request position data for a particular mobile field unit 52. It should be noted that there may be multiple instances of the same application 80, 83 running at any one time. Additionally, remote applications 81 from outside system 50 may also occasionally access system resources.

Enterprise computing system 50 also comprises a UDP server 87. UDP server 87 operates to receive and store position data received from mobile field unit 52 and 53. Common gateway interface (CGI) 89 is employed to retrieve position data and format the position data in response to requests for such data. According to one embodiment of the invention CGI 89 is written in the PERL scripting language.

Enterprise computing system 50 also comprises database server software 82 which may be, for example, an Oracle database server. Indeed, there may be multiple databases 82 in one system 50. Database server software 82 manages field unit position data, work order data as well as other business related data. For example, in the case of a utility, databases 82 might comprise detailed equipment data and map data.

Enterprise computing system further comprises HTTP servers 84 which may be, for example, a Netscape or Apache HTTP server. HTTP servers 84 are operable to field requests from all machines but particularly from web browsers located in mobile field unit 52.

Monitor server software 85 accepts updates from applications 80 indicating that a work order has been assigned. Monitor server software 85 also accepts updates as to whether the work order has been successfully transmitted to field unit 52 and whether it was accepted by the field crew. Monitor server 85 also provides a report generation feature.

Mobile field units 52 and 53 comprise various software components associated with position data unit 73. It should be noted that while mobile field unit 53 comprises position data unit 73, the specific software components of data unit 73 are shown only in field unit 52 for purposes of brevity. Position data unit 73 comprises UDP server 95 for receiving requests for position data. Preferably, UDP server 95 is multi-threaded meaning that it listens for requests and upon receipt of requests, spawns UDP client 96 to gather the requested position data and transmit it back to UDP server 87 on enterprise computing system 50. In this way, UDP server 96 can continue to listen for additional requests.

Position data unit 73 also comprises GPS interface 97 for interfacing with receiver 75. GPS processing software 98 processes data received from receiver 75 into an internally recognizable format. TCP/IP stack 99 is employed to communicate with radio modem 74. PPP server 100 may be employed to interface with other devices in mobile field unit 52 such as mobile computing device 72.

Mobile field unit 52 may also comprise mobile server application 86. Mobil server application 86 services requests from enterprise computing system 50 to mobile field unit 52. In a preferred embodiment, mobile server 86 is written in the JAVA programming language which allows for mobile server 86 to run on numerous hardware platforms running various operating systems such as Windows, Mac OS, or Unix. Mobile server 86 is multi-threaded meaning it listens for requests and upon receipt of an input, spawns process 88 to react to the input. In this way, mobile server 86 can continue to listen for additional requests.

Mobile field unit 52 also comprises web browser 90 which may be loaded with files 92 that are downloaded from enterprise computing system 50. Web browser enhancer 94 is loaded by web browser 90 to display maps and related data. Web browser enhancer 94 may be a plug-in that is initially

stored on mobile field unit 52. Alternatively, web browser enhancer 94 may be an Applet that is downloaded from enterprise computing system 50.

Figure 3 provides a view of the software components of an alternative software embodiment in accordance with the present invention that employs HTTP communications for distribution of field unit position data. As shown, the majority of software components are identical to those from the UDP embodiment described above with reference to Figure 2. However, with regard to enterprise computing system 50, where in the previous embodiment UDP server 87 and UDP position tracking application 83 were employed to retrieve field unit position data, in the embodiment of Figure 3, HTTP client application 110 both requests and receives field position data from mobile field unit 52.

With regard to mobile field units 52 and 53, position data unit 73 comprises HTTP server 112 for receiving and responding to requests for field unit position data. HTTP server 112 interacts with common gateway interface (CGI) program 114 to retrieve position data. Other components of position data unit 73 include receiver interface software 97, position processing software 98, and TCP/IP interface software 99 all of which operate identically to those shown in Figure 2 above.

Mobile field units 52 and 53 might also comprise various other components including mobile server 86, process 88, web browser 90 and web browser enhancer 94. These too operate as described above with reference to Figure 2.

Generally, mobile field unit 52 gathers position data from a positioning system and transmits position data to machines upon request. The requesting machine may be another mobile field unit 53 or a machine on enterprise computing system 50. Where the data is transmitted to enterprise computing system 50, the position data is stored and

distributed upon request to other mobile field units 53 or client applications 80 and 83.

Where position data is delivered directly from one mobile field unit to another, i.e. peer-to-peer, a mobile field unit 53 may operate as a mobile command center. As such, movement of mobile file units can be tracked on a mobile field unit. Furthermore, by delivering position data to both the computing system 50 and mobile field unit 53, the location of a mobile field unit 52 can be simultaneously tracked in both locations. In theory, numerous mobile field units may track the position data for one or more mobile field units. With the advent of unlimited usage CDPD, offerings the above scenarios become very attractive. This is due in particular to the relatively low overhead associated with UDP packets. Figure 4 illustrates connections being made directly between mobile field units 52 as well as between mobile field units 52 and enterprise computing system 50. One mobile field unit may be configured as a mobile control center and receive position data that is simultaneously transmitted to enterprise computing system 50.

Figure 5 provides a flow chart for the process of distributing position data from a mobile field unit 52 or 53. As shown, at step 120 position data for field unit 52 is gathered. At step 122 a request to transmit the position data to a particular machine, preferably identified by an IP address is received at mobile field unit 52. As explained in detail with reference to Figure 8 below, the request may be for either immediate transmittal of position data or for transmittal of position data at specific intervals. An exemplary screen for specifying a particular machine for which position data is desired is shown in Figure 6. Referring back to Figure 5, at step 124, depending upon the IP address specified in the request, the position data is routed over wireless network 54 to either another mobile field unit 53 or to enterprise computing system 50. If the

data is routed to enterprise computing system 50, at step 126 the position data is processed and stored in enterprise system 50. Thereafter, at step 128 enterprise computing system 50 in response to a request for position data from a mobile field unit 52 retrieves the stored position data. At step 130, the position data is formatted into a format which can be easily processed by a requesting mobile field unit. As will described below, typically this formatting step entails generating a file with a MIME type with the position data located therein as well as an HTML file with an embedded reference to the MIME file. At step 132, the formatted position data is transmitted to the mobile field unit. At step 134, requesting mobile field unit 53 loads the position data into web browser 90. Figure 7 is an exemplary screen showing plotted position data.

If at step 124, the position data was routed directly to a mobile field unit 53, at step 136 field unit 53 formats the position data. In this, the peer to peer scenario of transmitting position data, the position, velocity, and direction data is extracted from the received packets or data link. Typically, in the peer-to-peer scenario, history records are not maintained of position data, i.e. the previous position data is deleted. Thus, formatting of position data upon receipt at a mobile field unit directly from another mobile field unit may entail replacing the previous position data with the new position data. At step 138 the refreshed position data is loaded and displayed in web browser 90 with the aid of web browser enhancer 94. It should be noted that because history records are typically not maintained in the peer-to-peer scenario, if a crew wishes to display more than the current position for mobile field unit 52, i.e. the route, it is necessary to obtain this information from enterprise computing system 50.

At step 122 in Figure 5 a request for position data is processed at mobile field unit 52. Figure 8 provides a

detailed flow diagram of a process for processing a data request. As shown in Figure 8, at step 142 a request for position data is received at mobile field unit 52. The request may vary in terms of what exactly is requested. The request may be for position data to be sent immediately. Alternatively, the request may indicate that position data is to be transmitted periodically over specific intervals. The interval may be defined in terms of time or distance traveled by the mobile field unit 52. Furthermore, the request may define a primary and secondary device to which the position data should be transmitted. Communication of position data to a primary and secondary machine allows for the enterprise computing system 50 as well as another mobile field unit 53 to simultaneously monitor field locations for field unit 52.

If at step 144 the request is for immediate transmittal, at step 146 position data is immediately transmitted to the requesting machine. In an embodiment of the present invention such as is shown in Figure 2 wherein a UDP server 95 is employed in position data unit 73, the IP address and port number of the requesting machine may be extracted from the UDP packet of the request and the position data immediately transmitted to the address and port number.

If at step 144 the request is for position data to be sent at specified intervals, at step 148 position data is transmitted to the primary machine and possibly secondary machine as specified in the request. Thereafter, at step 150 it is determined if the specified interval, for example time or distance traveled, has been reached. If so, at step 148 updated position data is transmitted. If at step 150 the interval has not been reached, the process continues to wait at step 152.

In Figure 5, at step 126 enterprise computing system 50 processes the position data received from mobile field unit 52. The process steps that may be employed in the format operation are depicted in Figure 9. At step 160 the position

data received from mobile computing unit 52 is parsed. At step 162 latitude and longitude coordinates are calculated from the parsed position data. These latitude and longitude coordinates were taken relative to the earth's curved surface by the GPS system. A two-dimensional map such as exists in mobile field unit 53 does not account for the curvature of the earth. Thus, when mapping the GPS coordinates to two dimensional planar coordinates, it is necessary to adjust the coordinates. This occurs at step 164 where the latitude and longitude coordinates are converted to two-dimensional planar coordinates, usually for the state or region where field unit 52 is located. At step 166 velocity and direction statistics are extracted from the parsed position data. At step 168 the formatted position data is stored for later retrieval. As is explained in greater detail below, the position data may be stored in either a file or system database.

In Figure 5, at step 130 upon request of a mobile field unit, enterprise computing system 50 formats the position data in preparation for transmittal to a field unit. Figure 10 provides a detailed flow chart of the formatting process. At step 180 the formatted position data is stored in a first file. This first file is preferably a MIME file type and has a file name that ends with a ".mpx" extension. The formatting of the .mpx file is analogous to that described in co-pending PCT Patent Application serial no. (not yet assigned)(attorney docket no. ABME-0538), filed on even date herewith, and titled "Mobile Crew Management System." However, where in that application the data in the .mpx file represents map objects, in this case the data represents a series of position data points for a mobile field unit at various points in time. The series of position data points t can be connected and displayed as markers on a map to represent the route that a mobile field unit 52 has taken. Each marker represents an actual measurement. Different markers may be used to represent different mobile field

units. At step 182 a second file is generated. This second file is preferably an HTML file which can be loaded by web browser 90. The HTML file comprises an embedded reference to the .mpx file. Upon loading of the HTML file, web browser 90 detects the reference to the first file, i.e. the ".mpx" file and loads web browser enhancer 94 which is specially developed to display the contents of the .mpx file. In addition to performing other functions, web enhancer 94 overlays the route with land-based and network maps. The field location data can thereby displayed be in the web browser.

As noted previously, the present invention may be implemented using UDP technology or HTTP technology to transmit position data. Figure 11 depicts various command and data flows associated with transfer of position data that may be implemented in an embodiment of the invention employing UDP technology. The distribution of position data may begin with UDP position tracking application 83 at enterprise computing system 50 requesting, as shown by arrow 200, that position data for mobile field unit 52 be transmitted back to the enterprise computing system 50. At mobile field unit 52, the request is received at UDP server 95 (arrow 200). UDP server 95 spawns UDP client 96 to service the request (arrow 202). After retrieving the position data, UDP client 96 transmits the requested position data to UDP Server 95 on enterprise computing system 50 (arrow 204). UDP server 95 parses the position data, retrieves the latitude and longitude coordinates as well as the velocity and direction statistics, and converts the latitude and longitude coordinates to state plane coordinates. UDP Server 87 stores the processed position data with an indication of the IP address of mobile field unit 52. Generally, the processed position data is stored (arrow 206) in a system log file, referred to as gps.log 210. The position data is typically also saved in database 82 (arrow 208). The position data can

thereafter be retrieved from either location. It should be noted that flows 204 through 208 may be repeated on an interval basis if it was initially requested that the position data be so delivered. Where updated position data is repeatedly delivered on intervals over a period of time, the gps.log file and database 82 are appended to with the updated position data.

Generally, when a field crew or individuals at the enterprise computing system 50 desire to see position data for a particular field unit 52, they may do so by accessing the position data stored on enterprise computing system 50 via a web interface. In Figure 11, this process of accessing the stored position data is illustrated by means of an access from a mobile field unit 53. It should be noted, however, that this same process could be initiated from other locations including clients on enterprise computing system 50.

Typically, a user may specify the particular machine for which they wish to have position data using a web page such as that shown in Figure 6. As shown in Figure 6 a user may select a particular field unit 52 by selecting the IP address for the desired machine. Of course, other means of designating a particular mobile field unit 52 could alternatively be used, provided it uniquely identifies the unit.

For purposes of this exemplary illustration, it can be assumed that a request is made at field unit 53 for position data for field unit 52. At field unit 53, the request for position data is transmitted, as represented by arrow 212, to HTTP Server 84 on enterprise computing system 50. The request identifies that position data for field unit 52 is desired by including the IP Address of field unit 52. In one embodiment of the invention, flow 212 corresponds to an HTTP CGI Post connection between web browser 90 and HTTP server 84.

In response to the request, HTTP server 84 launches a CGI 89 which is preferably implemented as a PERL script (arrow 214). Using the IP address that was transmitted with the request, PERL script 89 searches for the stored position data. The position data may be stored in both a log file, gps.log 210, and database 82. The position data may be retrieved from either location using the IP address. For example, PERL script 89 may search gps.log file 210 for all position data related to the designated IP address.

Generally, the position data that is stored in enterprise computing system 50 has been gathered over intervals and may contain some inaccuracies in the position data. Thus, PERL script 89 may need to process the position data to account for these inaccuracies. Generally, PERL script 89 parses each line of gps.log file 210 or each record of database 82, extracting the state plane coordinates related to field unit 52. PERL script 89 stores the previous and current coordinates and checks for sudden changes in value. If the values are negative then they are ignored. Typically, negative values are an indication that the positioning system had not achieved a lock on the particular field unit when the position data was generated.

PERL script 89 may also ignore values for position data if the value represents a sudden change in position of the field unit that cannot be accounted for. PERL script 89 can delineate between spurious sudden change values and valid position data by considering values in relation to those that come before and follow. According to this sliding window algorithm, if a value represents a sudden change in position, but subsequent values for the position are consistent with this value, i.e. within a reasonable proximity, the value is considered to be valid. Such a sudden change may be caused for example when the field unit was off and subsequently turned on when the field unit was in an entirely new

location. If the change cannot be accounted for, however, it is discarded.

All position data values that are found to be valid are written to a first file 216 (arrow 218). In one embodiment the first file 216 is a MIME type file and has a file name ending ".mpx." Thereafter, PERL script 89 generates a second file 220, preferably an HTML file (arrow 222). HTML file 220 comprises a reference or an embedded tag to ".mpx" file 216. HTML file 220 and ".mpx" file 216 are transmitted via HTTP server 84 to field unit 53 (arrow 224). Upon receipt, HTML file 220 is loaded into web browser 90. Web browser 90 recognizes the reference to ".mpx" file 216 and in response loads web browser enhancer 94 which is operable to display the position data stored in ".mpx" file 216 (arrow 226). An exemplary screen that may be displayed upon loading of the position data in browser 90 is shown in Figure 7.

It should be noted that the display preferably graphically displays the velocity and direction to a location for each mobile field unit. For example, attached to each icon or marker on the map display, a vector may be drawn. The vector indicates direction of travel and the length of the vector is an indication of the speed of the mobile field unit. Of course, the velocity may also be drawn as text on the display.

It should also be noted that ".mpx" file 216 may encompass land-based data representing a sub-map which encompasses the coordinates of the mobile field unit route. Thus, browser enhancer 94 can overlay the mobile field unit route on a land-based map display. ".mpx" file 216 and html file 218 typically should have unique names. Otherwise, upon subsequent requests for position data for the same field unit, web browser 90 may display old map data instead of the newly downloaded data. Unique file naming mechanisms may include, for example assigning file names corresponding to the time and date a file was generated or by assigning unique

random numbers. A complete description of the contents and uses of ".mpx" file 216 and HTML file 218 is provided in co-pending PCT Patent Application serial no. (not yet assigned)(attorney docket no. ABME-0538), filed on even date herewith, and titled "Mobile Crew Management System," the contents of which are hereby incorporated by reference.

As previously noted, position data may be transmitted directly from one mobile field unit to another mobile field unit without first being stored on enterprise computing system 52. Thus, for purposes of illustration, a user at field unit 53 may designate to retrieve position data directly from field unit 52. Accordingly, a request is forwarded from web browser 90 of field unit 53 to UDP server 95 of field unit 52 (arrow 230). UDP server 95 launches UDP client 96 to gather the requested position data (arrow 232). UDP client 96 gathers the data and transmits it back to field unit 53 (arrow 234). Web browser 90 of field unit 53 receives the position data and loads web browser enhancer 94 so as to display the new position data (arrow 236).

It should be noted that typically requests for position data might first designate a primary and secondary machine by IP address and the port location which are to receive position data. Thereafter, in response to these requests, UDP packets containing position data are transmitted to the primary and secondary machines. Position data may be transmitted at intervals if specified as such in the request. Of course if no primary or secondary addresses are specified, position data is not sent. Thus, the first embodiment of the invention allows for two or more machines to simultaneously receive position data for the same mobile field unit. As noted previously, this allows for a mobile field unit to receive position data and operate as a mobile control center while position data is simultaneously provided to enterprise computing system 50.

A second embodiment of the system for distributing position data employs HTTP communications to distribute position data from a mobile field unit. Figure 12 depicts the data and command flows for such an embodiment. Typically a request for position data is made via HTTP position tracking application 110 and involves making an HTTP client connection with the selected mobile field unit 52 (arrow 300). Upon receipt, HTTP server 112 requests CGI program 114 handle gathering the requested position data (arrow 302). CGI program 114 requests position data from position processing application 98 (arrow 304). Position processing application 98 returns the requested position data to CGI program 114 (arrow 306). CGI program 114 returns the position data to HTTP application 110 (arrow 308). HTTP application 110 stores the position data in gps.log file 210 and database 82 (arrow 310).

The process of retrieving position data from enterprise computing system 52 to mobile field unit 53 in the system of Figure 12 is generally identical to that described above with reference to Figure 11. As such, the numbering for the corresponding flows (arrows 212 through 226) have been numbered the same.

In the case of retrieving position data from field unit 52 directly to field unit 53, the process is only slightly different from that described above in connection with Figure 10. Accordingly, a request is forwarded from web browser 90 of field unit 53 to HTTP server 112 of field unit 52 (arrow 330). HTTP server 112 launches CGI program 114 to gather the requested position data (arrow 332). CGI program 114 gathers the data and transmits it back to field unit 53 (arrow 334). Web browser 90 of field unit 53 receives the data and loads web browser enhancer 94 so as to display the new position data (arrow 336).

Although the flow is generally same for the UDP and HTTP implementations of the present invention. There are a

few slight differences in the capabilities of the systems. The present implementation does not provide for position data to be transmitted at intervals as a result of a single request. Rather, a request is typically sent each time position data is required, even for updates. Of course it is possible and certainly envisioned that an HTTP embodiment that allows for transmission of position data at intervals. Furthermore, the HTTP embodiment does not presently provide for a single request that results in a primary and secondary machine to be designated and simultaneously receive position data. However, this functionality can be duplicated in the HTTP embodiment by generating a list of machines to which position data should be transmitted, and each time position data is requested, a request is made for each machine in the list.

Thus, as described above the present invention provides systems and methods for low-cost and timely communication of field unit position data between a field unit, a central enterprise system, and secondary field units. The system comprises an enterprise computing system, a wireless network, and multiple mobile field units. Communications are TCP/IP-based and can be carried over a public or private network using a variety of communications technologies.

While the invention has been described and illustrated with reference to specific embodiments, those skilled in the art will recognize that modification and variations may be made without departing from the principles of the invention as described above and set forth in the following claims. In particular, the present invention has been explained with reference to an exemplary utility environment but may be employed in other environments such as maintenance service corporations, ambulance services, public safety systems or any other operation which communicates work orders to field personnel. Furthermore, it should be noted that position data may be displayed according to the methods and systems of

the present invention in an application other than a web browser. Accordingly, reference should be made to the appended claims as indicating the scope of the invention.

What is claimed is:

1. A crew locator system for distributing field crew position data gathered from a global positioning system to a geographically distributed field crew, comprising:

a wireless communication network;

an enterprise computing system in communication with said wireless network, said enterprise computing system operable to receive field crew position data, store the field crew position data, and in response to requests for the field crew position data transmit the field crew position data; and

a first mobile field unit in communication with said wireless network, said first mobile field unit operable to gather position data transmitted from a global positioning system and transmit the field crew position data to said enterprise computing system.

2. The crew locator system of claim 1 wherein the position data comprises values corresponding to location, speed, and direction of said first mobile field unit.

3. The crew locator system of claim 1 further comprising a second mobile field unit in communication with said wireless communication network, said second mobile field unit operable to request the field position data from said enterprise computing system and display the field position data.

4. The crew locator system of claim 3 wherein said second mobile field unit is further operable to request position data directly from said first mobile field unit and display the position data.

5. The crew locator system of claim 1, wherein said first mobile field unit comprises a receiver operable to

receive global position data transmitted from a global positioning system, a modem operable to transmit the field position data over said wireless network, and a first processor.

6. The crew locator system of claim 5 wherein said first processor has executable instructions thereon for communicating with said wireless radio modem, communicating with said receiver, processing position data received from said receiver, accepting requests for position data, and transmitting position data upon request.

7. The crew locator system of claim 3, wherein said second mobile field unit comprises a display for displaying position data, server software for receiving the position data, and browser software for browsing and interacting with web pages.

8. The crew locator system of claim 1, wherein said enterprise computing system formats the position data into a first file and a second file prior to transmitting the position data.

9. The crew locator system of claim 8, wherein said first file is a MIME type file and said second file is an HTML type file and contains a reference to said first file.

10. The crew locator system of claim 1, wherein said first field unit is operable to transmit field position data either immediately in response to a request or at regularly scheduled intervals.

11. The crew locator system of claim 10 wherein said regularly scheduled intervals are timed intervals.

12. The crew locator system of claim 10 wherein said regularly scheduled intervals are based on distance traveled by said mobile field unit.

13. The crew management system of claim 1, wherein said wireless communication network supports TCP/IP communication protocol.

14. The crew locator system of claim 5, wherein said mobile field unit further comprises a mobile computing device having a computing processor.

15. The crew locator system of claim 14, wherein said computing processor and said first processor are the same processor.

16. The crew locator system of claim 15, wherein said first processor is in communication with said radio modem over a serial port.

17. The crew locator system of claim 5, wherein said first processor has instructions thereon for implementing a UDP server and a UDP client application for fielding requests for position data.

18. The crew locator system of claim 5, wherein said UDP server is operable to receive a command to transmit position data.

19. The crew locator system of claim 18, wherein said command is to determine the internet protocol address and port address of the machine from which the command was sent and immediately transmit a UDP packet with position data to said internet protocol address and said port address.

20. The crew locator system of claim 18, wherein said command is to store a primary destination internet protocol address and transmit position data to said primary address at specified intervals.

21. The crew locator system of claim 18, wherein said command is to store a secondary destination internet protocol address and transmit position data to said secondary address at specified intervals.

22. The crew locator system of claim 20, wherein said interval is defined in time.

23. The crew locator system of claim 20, wherein said interval is defined in distance traveled.

24. The crew locator system of claim 1, wherein said enterprise computing system comprises an enterprise UDP server for receiving and processing position data transmitted from said first mobile unit.

25. The crew locator system of claim 1, wherein said enterprise computing system further comprises a wireless tcp/ip radio modem in communication with said enterprise UDP server and from which position data is received from said first mobile field unit.

26. The crew locator system of claim 24, wherein said enterprise UDP server parses the position data and stores the position data in at least one file.

27. The crew locator system of claim 24, wherein said enterprise UDP server parses the position data and stores the position data in a database.

28. The crew locator system of claim 1, wherein said enterprise computing system further comprises an HTTP server for receiving HTTP requests and a plurality of common gateway interface scripts for interfacing with the stored position data.

29. The crew locator system of claim 28, wherein said HTTP server is in operable communication with said wireless radio modem and thereby can accept a position data request from said second mobile field unit, process said position data requests, and return position data.

29. The crew locator system of claim 28, wherein said HTTP server upon receiving position data request causes a first of said plurality of common gateway interface scripts to access said database, generate a HTTP field unit list page, and transmit said HTTP field unit list page to said HTTP server for transmitting to said second mobile unit, said HTTP field unit list page causing a list of field units to be displayed when loaded in a web browser.

30. The crew locator system of claim 28, wherein said HTTP server upon receiving position data request causes a second of said plurality of common gateway interface scripts to retrieve position data from said database relevant to one of said field units defined in said HTTP field unit list page and return said position data to said HTTP server for transmitting to said second field unit.

31. The crew locator system of claim 30, wherein said position data comprises a first file and a second file.

32. The crew locator system of claim 31, wherein said first file is an HTML file.

33. The crew locator system of claim 31, wherein said second file is a MIME type file.

34. The crew locator system of claim 33, wherein said second file comprises values corresponding to location, velocity, and direction.

35. The crew locator system of claim 1, further comprising:

a third mobile field unit in communication with said wireless network, said third mobile field unit operable to request the field position data from said first mobile field unit, received the field position data, and display the field position data, wherein said first mobile field unit is operable to transmit the field crew position data to said third mobile field unit.

36. The crew locator system of claim 1, wherein said first mobile field unit is operable to simultaneously transmit the field crew position data to said third mobile field unit and said enterprise computing system.

37. A method for distributing field crew position data in a system having a plurality of mobile field units, an enterprise system, and a TCP/IP wireless network, comprising the following steps:

(a) at a first mobile field unit, gathering and processing position data;

(b) at the first mobile field unit, receiving and processing a request to forward the position data to the enterprise system;

(c) at the first mobile field unit, transmitting the position data to the enterprise system;

(d) at the enterprise system, processing and storing the position data;

(e) at the enterprise system, in response to a request for positioning data from a second mobile field unit, retrieving the position data;

(f) at the enterprise system, formatting the position data;

(g) at the enterprise system, transmitting the position data to the second mobile field unit; and

(h) at the second mobile field unit, displaying the position data.

38. A method for receiving and storing position data in a system having a plurality of mobile field units, an enterprise system, and a TCP/IP wireless network, comprising the following steps:

(a) at the enterprise system, receiving position data;

(b) parsing the position data;

(c) retrieving latitude and longitude coordinates from the position data;

(d) retrieving velocity and direction statistics from the position data;

(e) converting the latitude and longitude coordinates to plane coordinates; and

(f) storing the plane coordinates, velocity, and direction.

39. A method for formatting position data in a system having a plurality of mobile field units, an enterprise system, and a TCP/IP wireless network, comprising the following steps:

(a) at the enterprise system, retrieving the position data;

(b) generating a first file comprising the position data;

(c) generating a second file, said second file being loadable by a web browser and having a reference to said

first file wherein upon loading said second file in a web browser, the web browser loads displays the position data stored in said first file.

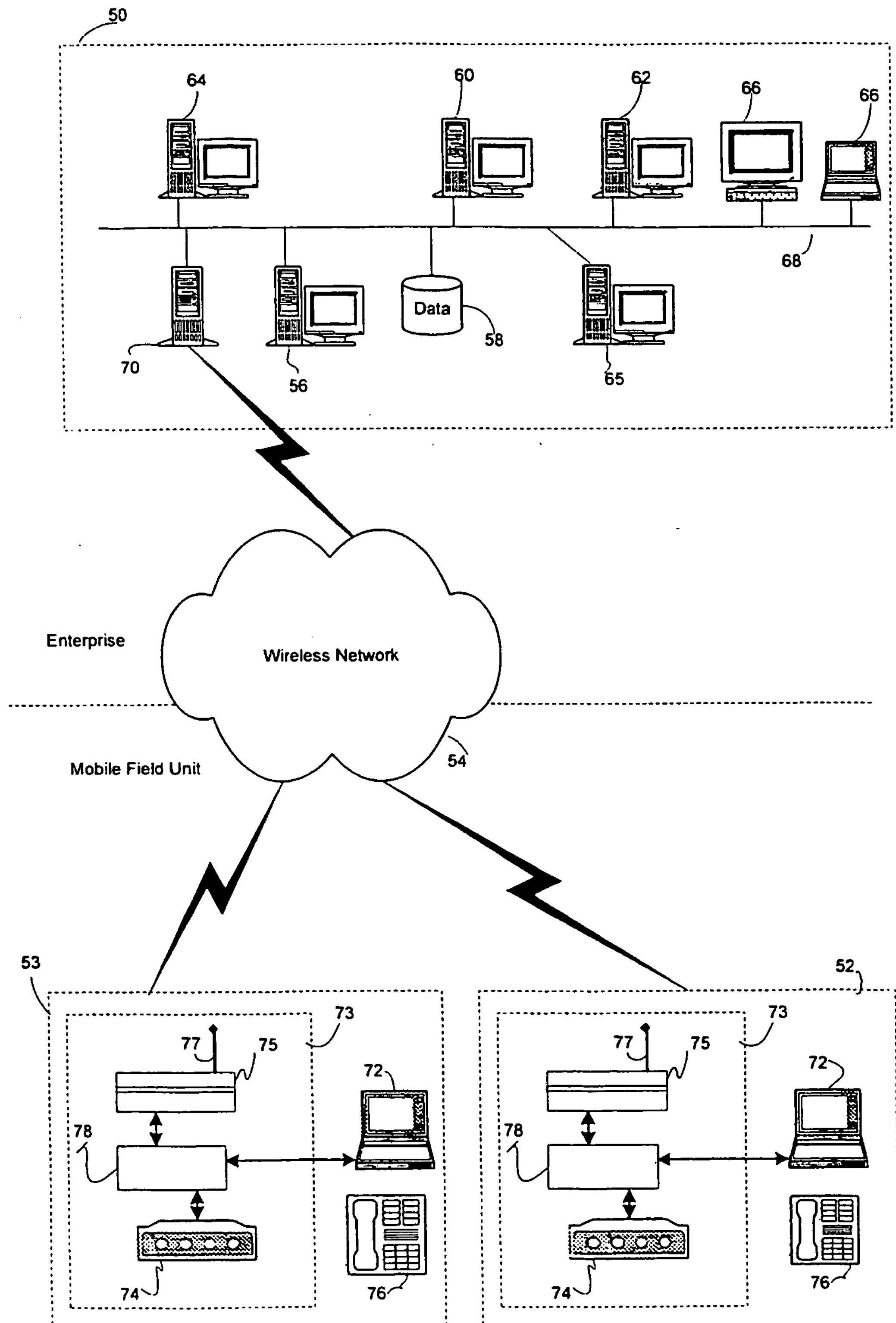
50
64
60
62
66
66
68
70
56
Data
58
65
Enterprise
Wireless Network
Mobile Field Unit
54
53
52
73
77
75
72
78
74
76

FIGURE 1

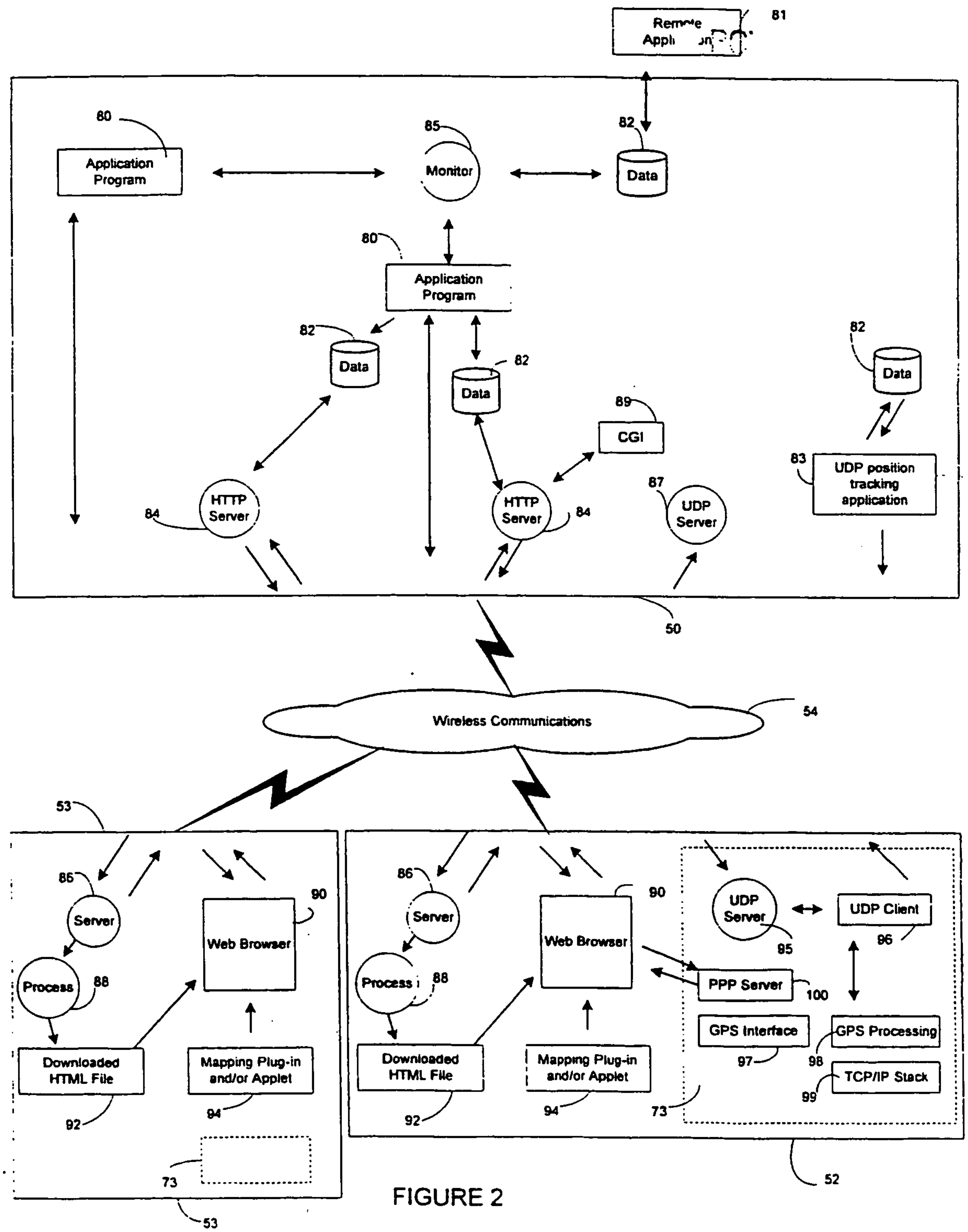
81
80
Application Program
85
Monitor
82
Data
80
Application Program
82
Data
82
Data
82
Data
89
CGI
83
UDP position tracking application
84
HTTP Server
HTTP Server
84
87
UDP Server
50
Wireless Communications
54
53
86
Server
Web Browser
90
Process
88
Downloaded HTML File
Mapping Plug-in and/or Applet
92
94
73
53
86
Server
Web Browser
90
UDP Server
UDP Client
95
96
Process
88
PPP Server
100
GPS Interface
GPS Processing
97
98
TCP/IP Stack
99
Downloaded HTML File
Mapping Plug-in and/or Applet
92
94
73
52

FIGURE 2

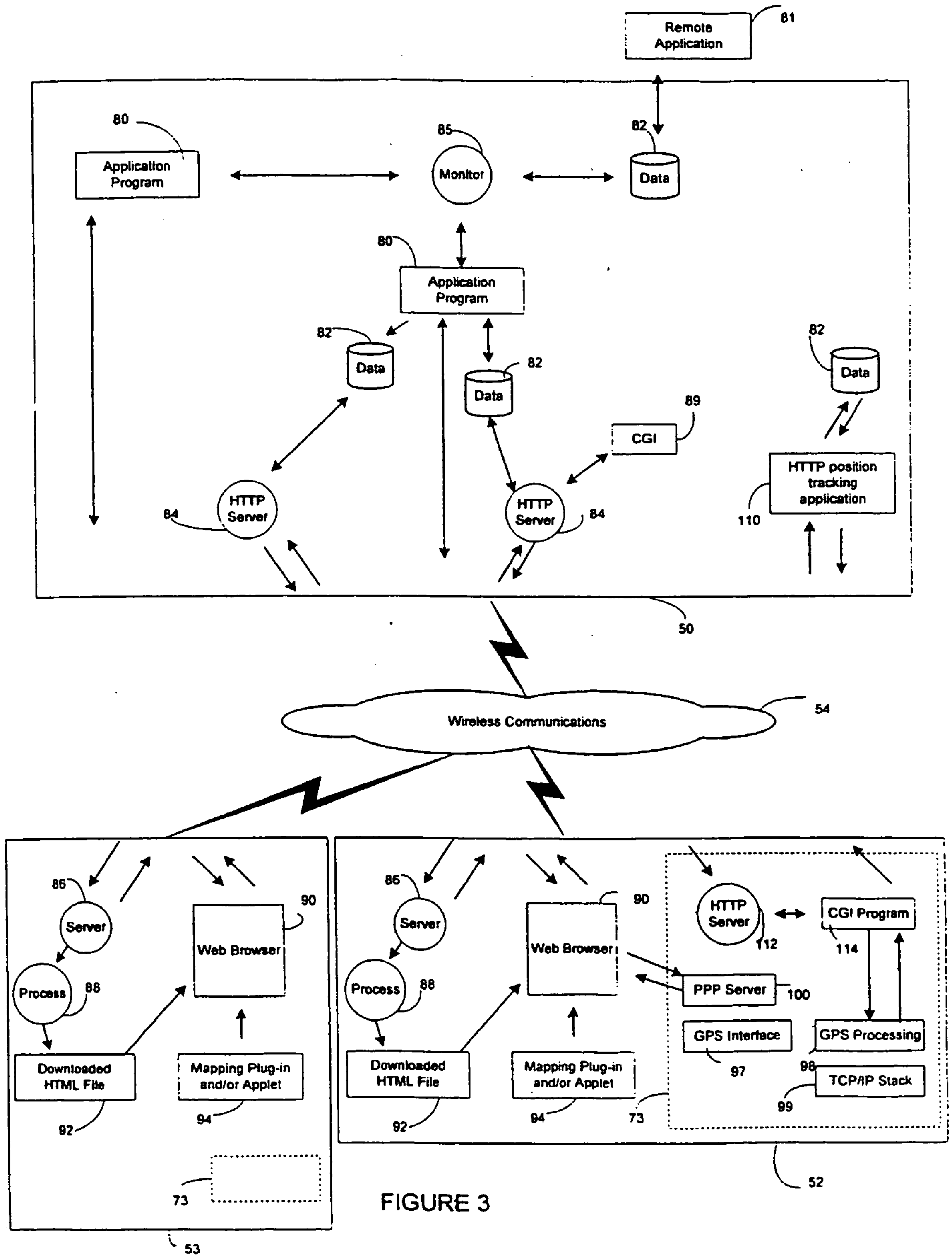
Remote Application
81
80
Application Program
85
Monitor
82
Data
80
Application Program
82
Data
82
Data
82
Data
89
CGI
HTTP position tracking application
110
HTTP Server
84
HTTP Server
84
50
Wireless Communications
54
86
Server
Process
88
Web Browser
90
Downloaded HTML File
92
Mapping Plug-in and/or Applet
94
73
53
86
Server
Process
88
Web Browser
90
Downloaded HTML File
92
Mapping Plug-in and/or Applet
94
73
HTTP Server
112
CGI Program
114
PPP Server
100
GPS Interface
97
GPS Processing
98
TCP/IP Stack
99
52

FIGURE 3

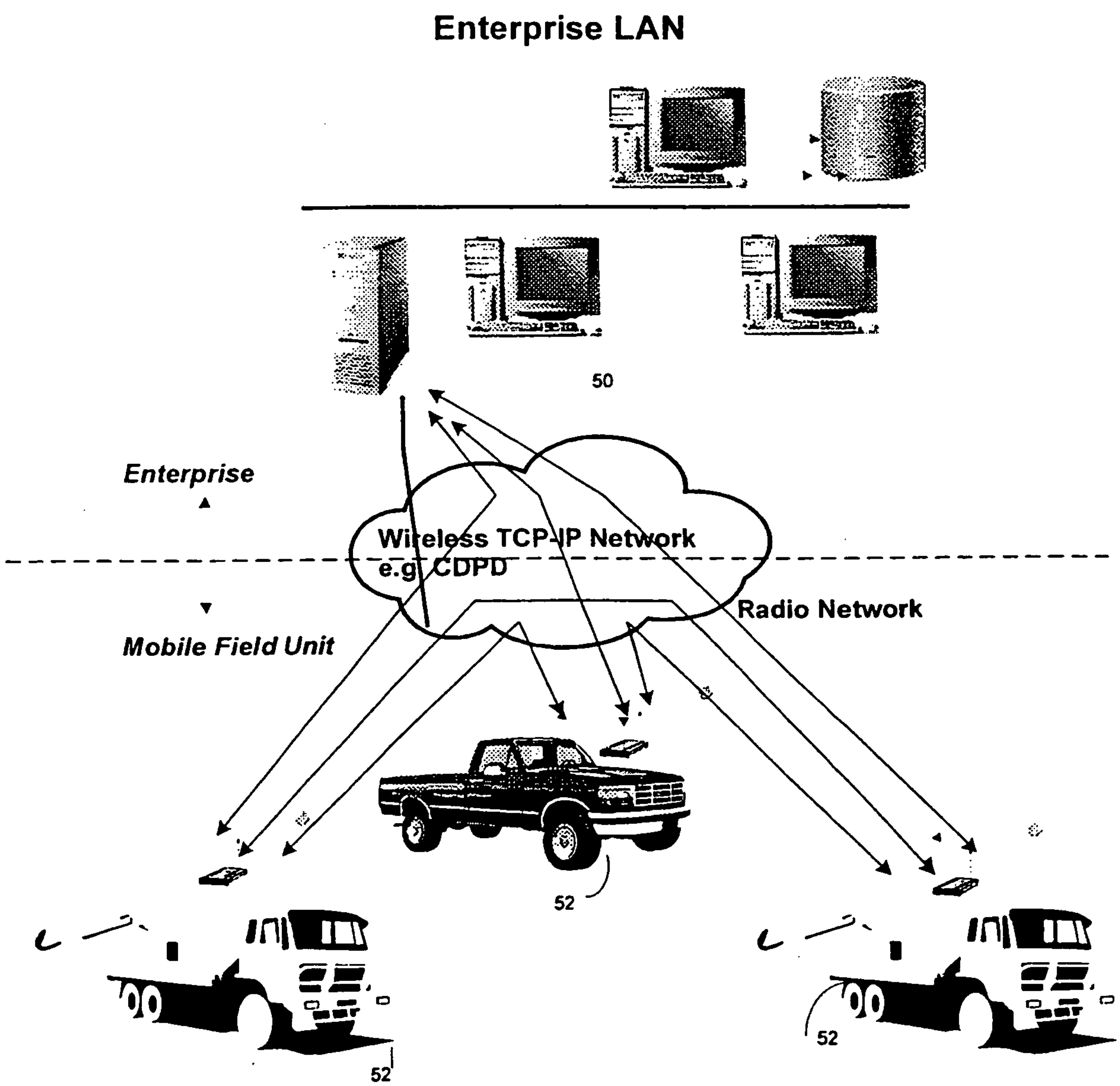
Enterprise LAN
50
Enterprise
Wireless TCP-IP Network
e.g. CDPD
Radio Network
Mobile Field Unit
52
52
52

FIGURE 4

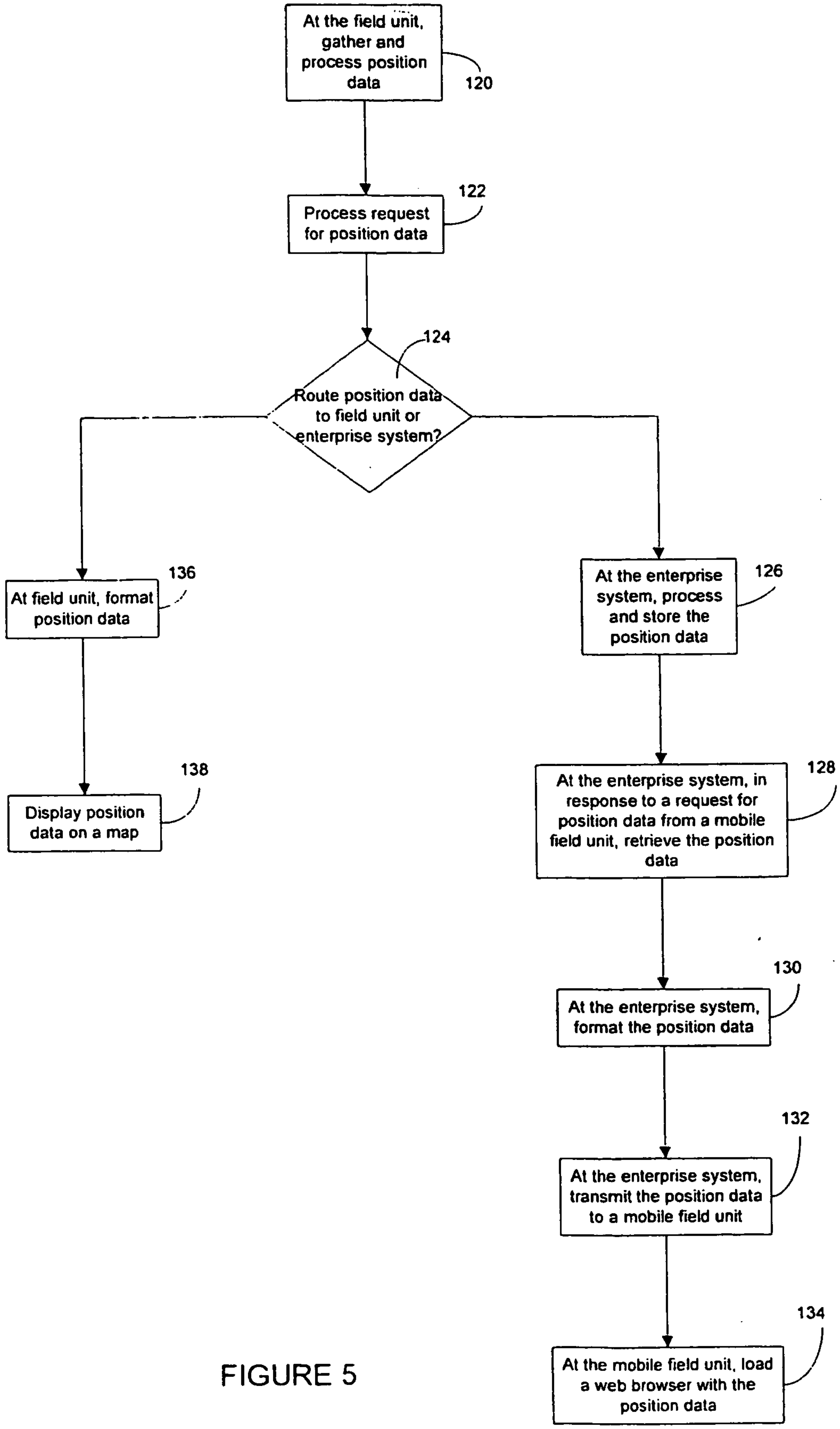
At the field unit, gather and process position data
120
Process request for position data
122
Route position data to field unit or enterprise system?
124
At field unit, format position data
136
Display position data on a map
138
At the enterprise system, process and store the position data
126
At the enterprise system, in response to a request for position data from a mobile field unit, retrieve the position data
128
At the enterprise system, format the position data
130
At the enterprise system, transmit the position data to a mobile field unit
132
At the mobile field unit, load a web browser with the position data
134

FIGURE 5

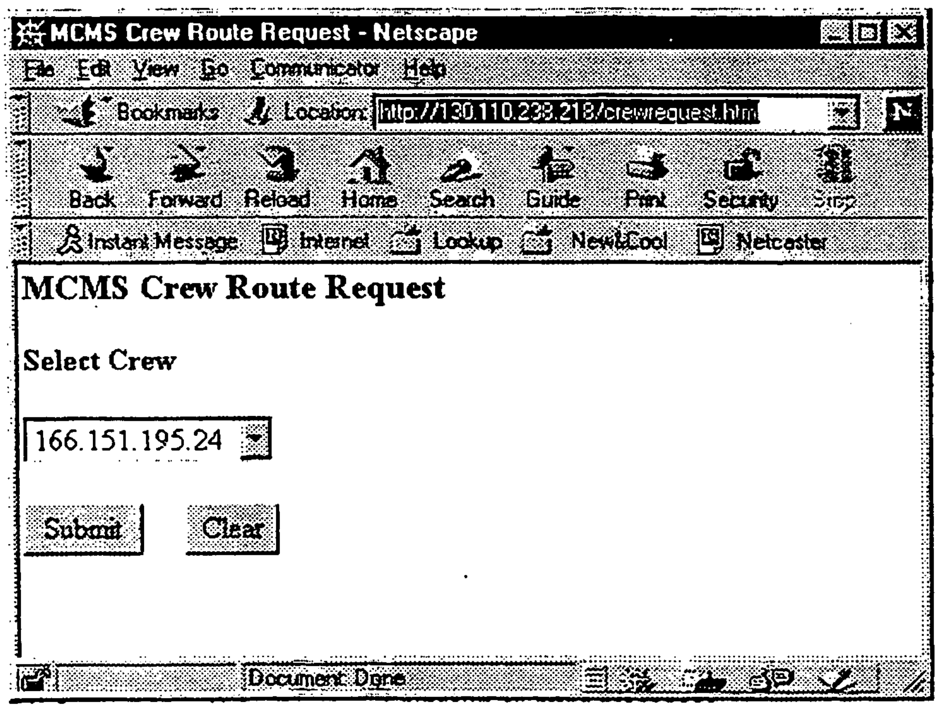
MCMS Crew Route Request - Netscape
File Edit View Go Communicator Help
Bookmarks Location: http://130.110.238.218/crewrequest.html
Back Forward Reload Home Search Guide Print Security Stop
Instant Message Internet Lookup New&Cool Netcaster
MCMS Crew Route Request
Select Crew
166.151.195.24
Submit Clear
Document: Done

FIGURE 6

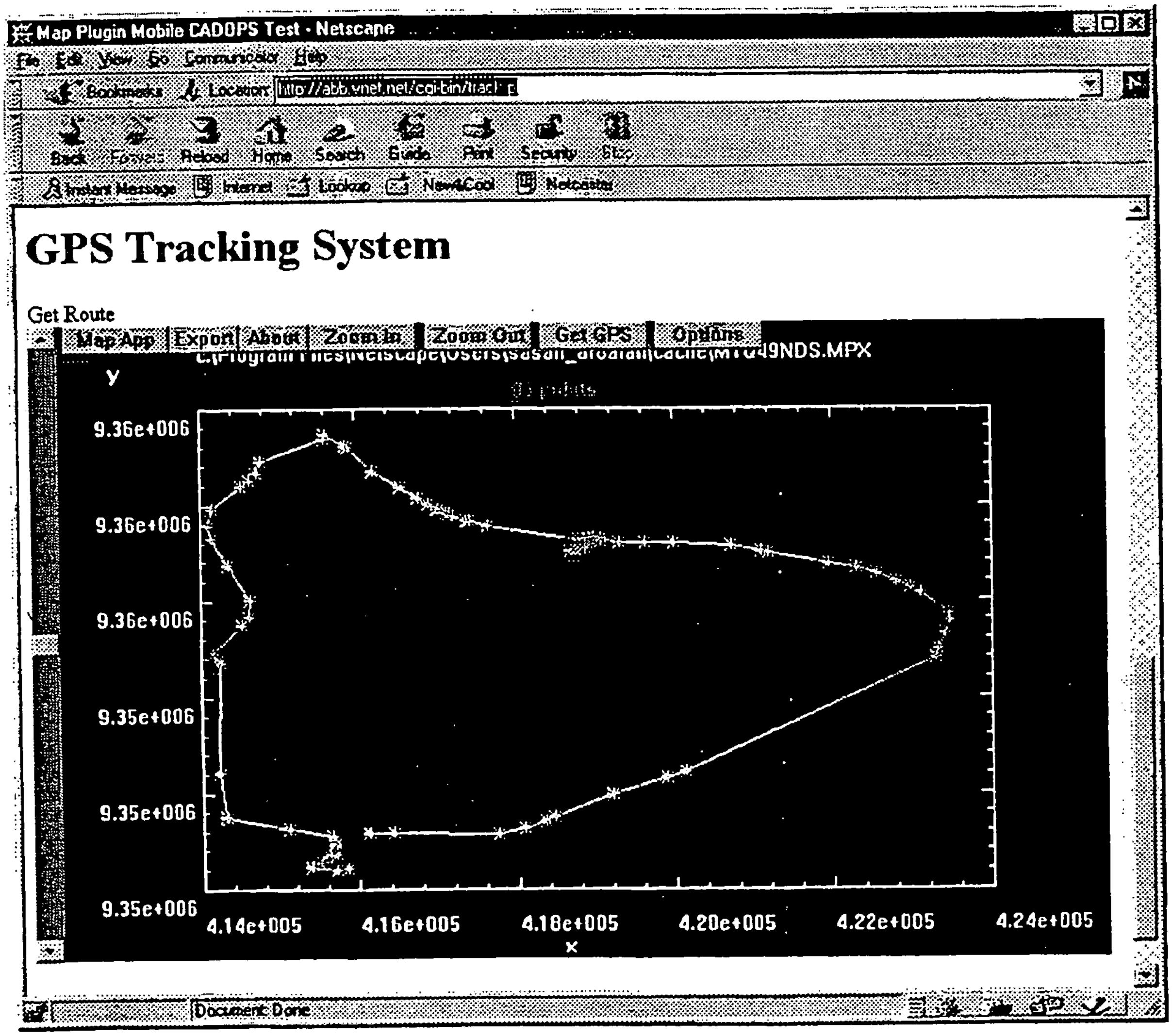
Map Plugin Mobile CADOPS Test - Netscape
GPS Tracking System
Get Route
Map App
Export
About
Zoom In
Zoom Out
Get GPS
Options
y
9.36e+006
9.36e+006
9.36e+006
9.35e+006
9.35e+006
9.35e+006
4.14e+005
4.16e+005
4.18e+005
4.20e+005
4.22e+005
4.24e+005
x
Document: Done

FIGURE 7

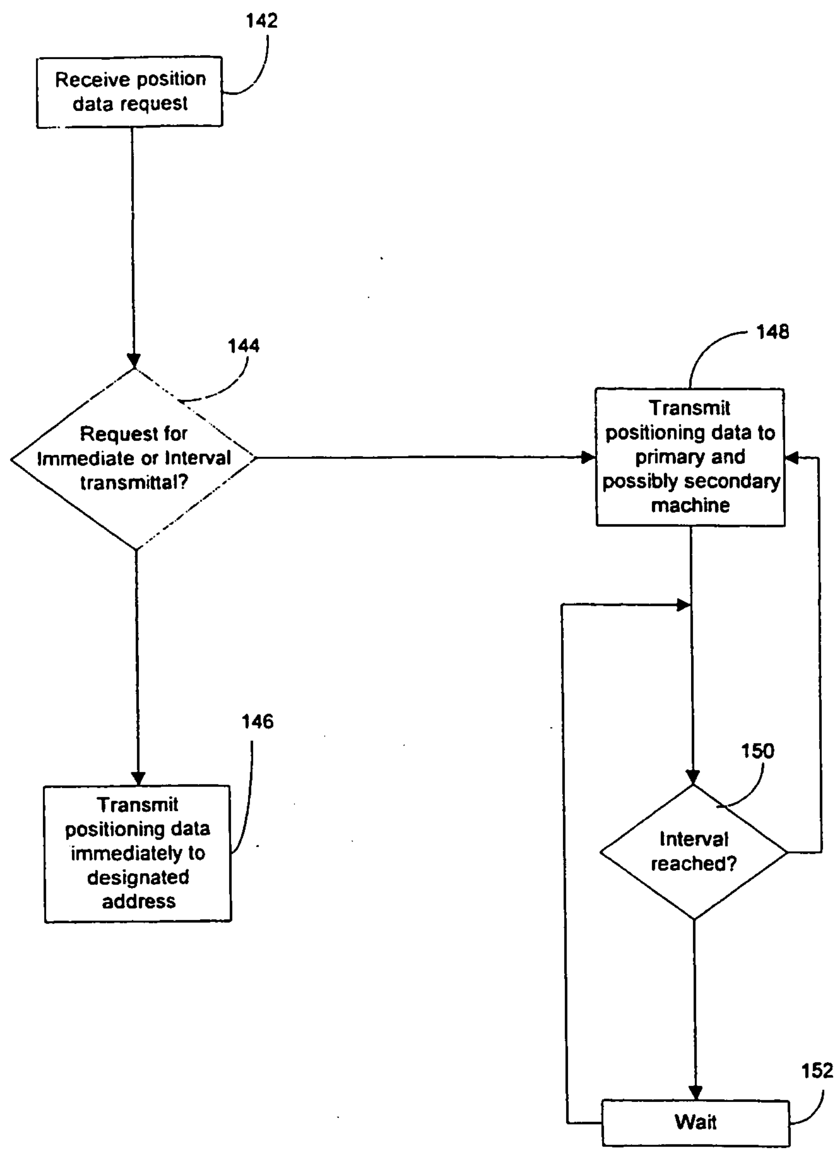
142
Receive position data request
144
Request for Immediate or Interval transmittal?
146
Transmit positioning data immediately to designated address
148
Transmit positioning data to primary and possibly secondary machine
150
Interval reached?
152
Wait

FIGURE 8

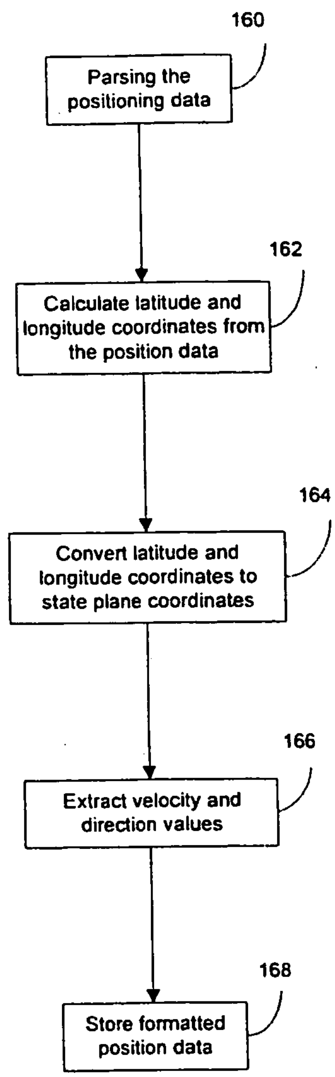
160
Parsing the positioning data
162
Calculate latitude and longitude coordinates from the position data
164
Convert latitude and longitude coordinates to state plane coordinates
166
Extract velocity and direction values
168
Store formatted position data

FIGURE 9

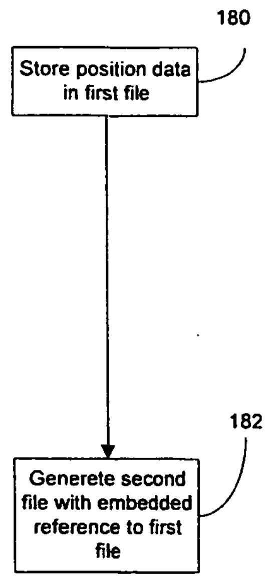
180
Store position data in first file
182
Generete second file with embedded reference to first file

FIGURE 10

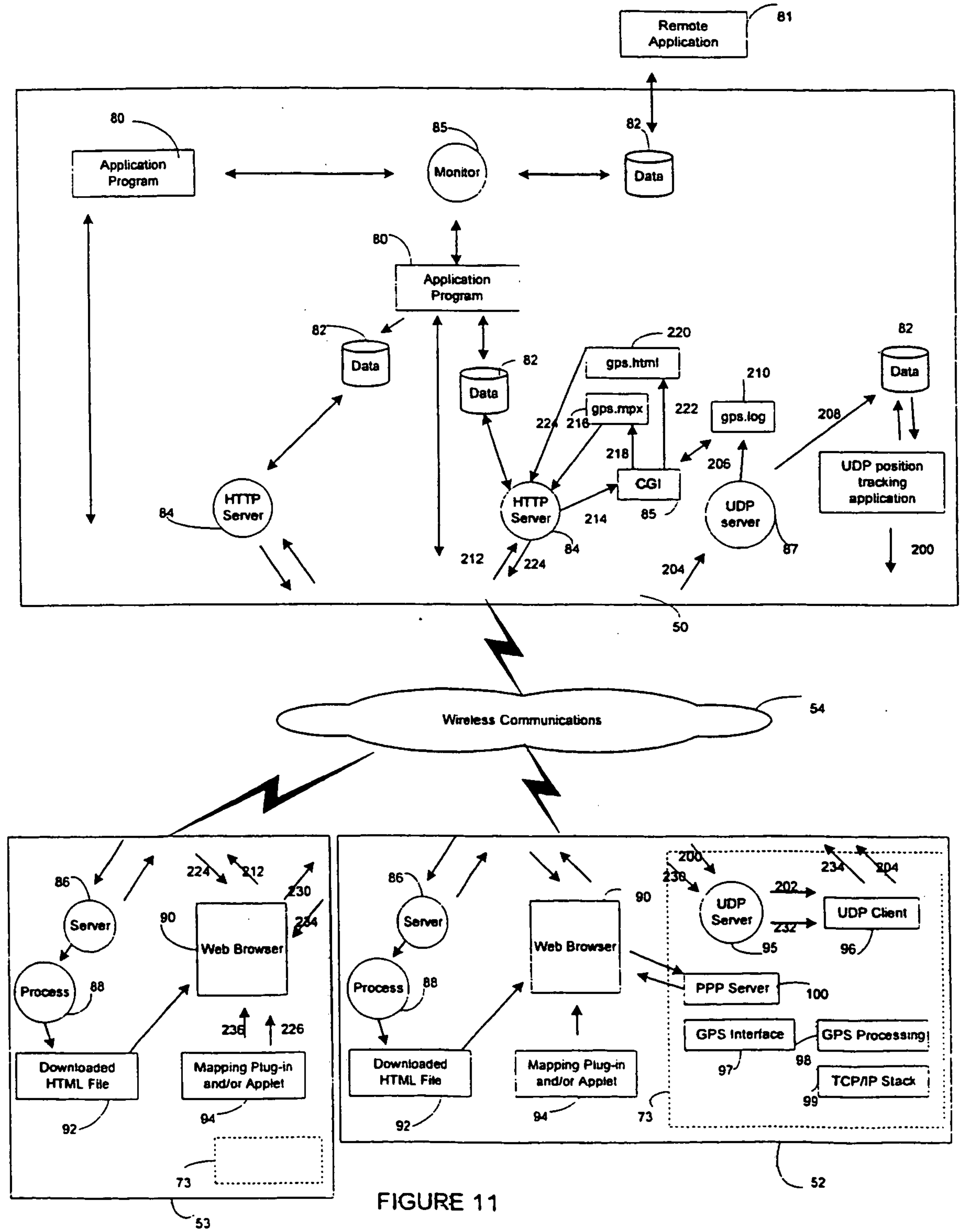
Remote Application
81
Application Program
80
85
Monitor
82
Data
Application Program
Data
gps.html
220
gps.mpx
216
222
gps.log
210
208
Data
218
206
CGI
UDP position tracking application
HTTP Server
84
214
85
UDP server
87
212
224
204
200
50
Wireless Communications
54
86
Server
Process
88
Downloaded HTML File
92
Web Browser
90
230
234
236
226
Mapping Plug-in and/or Applet
94
73
53
UDP Server
95
202
232
UDP Client
96
PPP Server
100
GPS Interface
97
GPS Processing
98
TCP/IP Stack
99
52

FIGURE 11

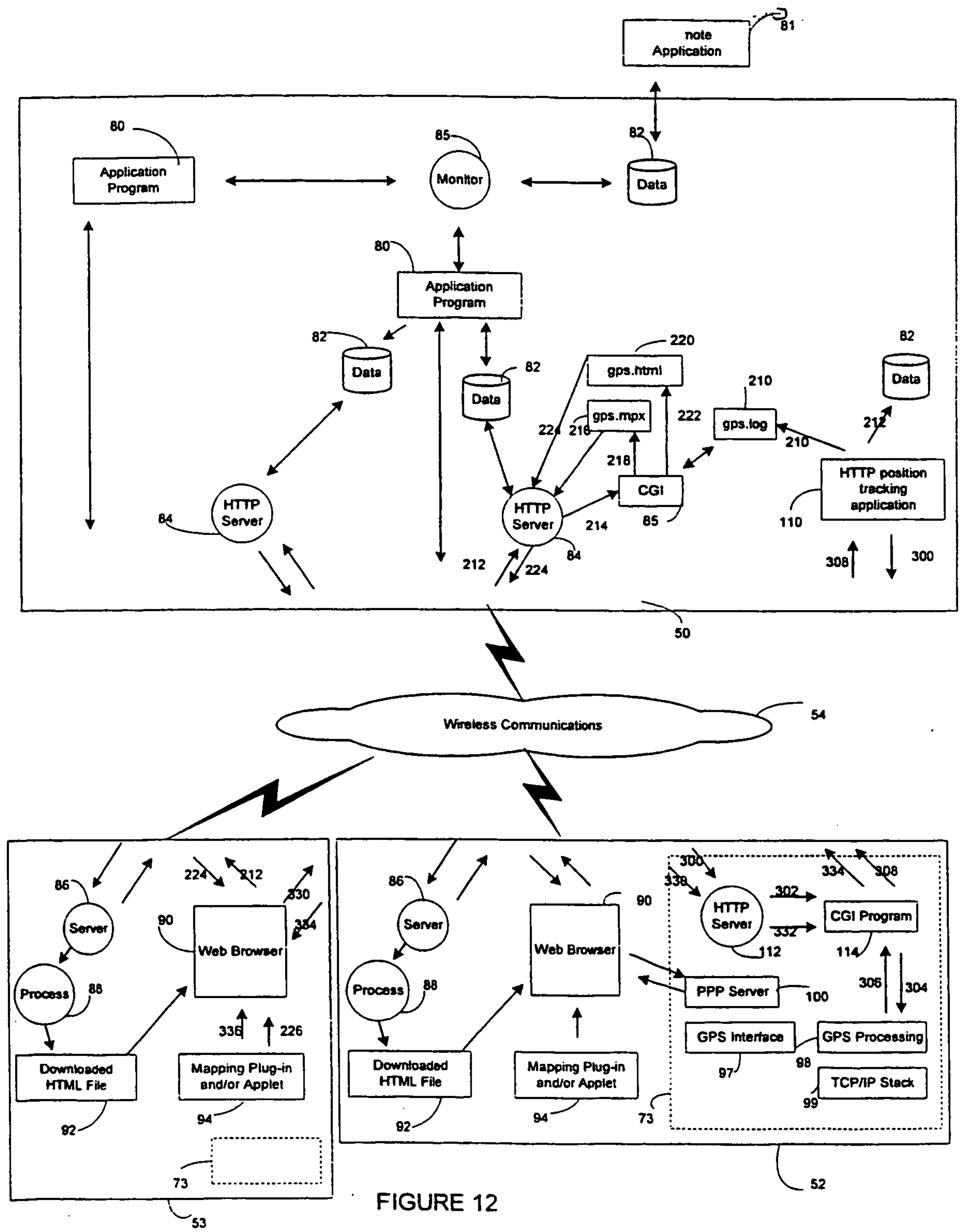
note Application
81
80
Application Program
85
Monitor
82
Data
80
Application Program
82
Data
82
Data
220
gps.html
gps.mpx
224
216
222
210
gps.log
212
210
82
Data
218
CGI
HTTP position tracking application
84
HTTP Server
HTTP Server
214
85
110
212
224
84
308
300
50
Wireless Communications
54
86
Server
224
212
330
90
Web Browser
334
Process
88
336
226
Downloaded HTML File
Mapping Plug-in and/or Applet
92
94
73
53
86
Server
90
Web Browser
Process
88
Downloaded HTML File
Mapping Plug-in and/or Applet
92
94
73
300
330
HTTP Server
302
332
112
CGI Program
334
308
114
306
304
PPP Server
100
GPS Interface
GPS Processing
97
98
TCP/IP Stack
99
52

FIGURE 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/00498

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :G06F 13/00
US CL : 340/990
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 340/988,989,990,991,992,993,994; 364/400; 370/242,399,395,397,471; 709/200,220,224

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS search terms, (crew# or vehicle#)(1a)(track? or locat?) and network#

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,636,122 A (SHAH et al.) 03 JUNE 1997, Abstract figures 5-14, col. 3 (line 1) to col. 4 (line 20-et seq.).	1-39

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 APRIL 1999	07 MAY 1999

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	ROBERT B. HARRELL Eugenia Logan
Facsimile No. (703) 305-3230	Telephone No. (703) 305-9692